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Generally Speaking

Let the People Know

As we promised in our last issue, we are devoting this number largely to the reports of the I.E.A. and the Gauge and Tool Exhibitions in London, and the Universal exhibition, 'EXPO 58', in Brussels. The last-named is a most interesting show, but we believe that from the point of view of our readers, the Gauge and Tool Exhibition offers the greatest amount of matter of immediate interest, and we have accordingly given the greatest amount of space to this report. It is four years since the last Gauge and Tool Exhibition was held, and in that time, a number of advances has been made, both in the industry generally, and in particular in the use of diamond tools. Sir William Lyon, managing director of the Jaguar car company—a firm with an enviable export record—who performed the opening ceremony, said in his speech that perhaps few members of the general public realized how much industry in general owed to the efforts of the gauge and tool industry. This is certainly and unfortunately true, but by holding an exhibition such as this, the Gauge and Tool Makers Association is doing its best to remedy the situation.

Space-saving

There has been some correspondence recently in the Manchester Guardian on the subject of micro-photographs, and this led to a discussion on microscopic engravings on glass. We have in our possession one of the engraved microscope slides prepared by W. Webb for Watson's of Holborn, on which a four-line epigrammatic verse has been engraved with a diamond point. Since the whole space occupied by the words is less than one millimetre by half a millimetre, we would not have been able to read it, nor to see that the engraving is in a beautiful copperplate hand, had we not had a powerful microscope with which to look at it. There may not be any great use in such curiosities in themselves, but the skill and accuracy of working that goes into their production must always be of value.

In the same class comes one of the exhibits in the Diamond Pavilion at the Brussels Exhibition, claimed to be the smallest gem in the world. It is a properly cut brilliant, with the full number of 58 facets, weighing only 0.0012 carat—one of the crown jewels of Lilliput !

All Very Fine

We read of a new design for a microtome made by E. Leitz (Instruments) Ltd to the design of Dr F. Moran, with which it is possible to cut reproducible sections 100 angstrom units thick; this is four times thinner than the average achieved by conventional instruments. The equipment is intended for use with a diamond blade, and can accordingly be used for cutting sections of hard materials. The difficulty with all such apparatus is controlling the rate of feed of the specimen; in a similar device, shown at the Physical Society exhibition four years ago, the advance was controlled by thermal expansion, using a material—Invar—with a low coefficient of expansion for the activating unit, and the same method is used in this instrument. In any case, where such dimensions are concerned, strict temperature control of the whole equipment is a first essential for reproducible results.

The New College at Cambridge

The proposal to found a new college at Cambridge, to be called after Sir Winston Churchill, and to be principally concerned with scientific and technological studies, is of great interest to the engineering industries. It is to be hoped that the £3,500,000 for which the trustees are appealing will soon be forthcoming, so that the college can set to work as soon as possible on its professed task of training a *corps d'elite* for British technology.

ADAMANT

Bigger - and - better - Gauge & Tool Exhibition

Industrial diamonds at Olympia

The latest developments in diamond tooling were on show at the Gauge & Tool Exhibition, held in the National Hall, Olympia, from May 12-21. The country's principal diamond tool manufacturers were represented, and several of their exhibits were being shown to the public for the first time. The Exhibition was larger—four times larger—than in previous years, sufficient proof that the industry is determined to combat the intense foreign competition in this field.

The following firms were represented at the Gauge & Tool Exhibition:

Impregnated Diamond Products Limited

A contrast in sizes and uses was provided by items from the Neven range of diamond tools, as both large diameter concrete cutting saws and small internal grinders were included in the display. The 920 series of cup wheels, for use in grinding tungsten carbides, was a feature of the display. Other established products, such as the peripheral wheels, cutting disks, etc, were included.

Demonstrated for the first time in public was the GF-O bench type oscillating grinding and lapping machine, designed for use with Neven diamond-impregnated wheels. The maximum tool height acceptable under the reversible guard is 1¾ in., and the reversible guard permits both left- and right-hand lathe tools to be lapped with equal efficiency. The oscillating motion eliminates the need for experienced operators, as the operator is simply required to rest the tool on the table and press it gently against the wheel. The design is claimed to give diamond wheels an extended life, owing to even distribution of wear across the face of the wheel. The machine is intended to operate with a Neven 6 in. diameter wheel, with either a ¾ or ⅝ in. wide impregnated rim. Neven medium 120/160 is the standard grade supplied, but the machine is equally suitable for use with very fine wheels for imparting mirror finishes. Though designed primarily for use on tungsten carbides, on which a surface finish of ½ micro-inch can be produced, it is also recommended for lapping the ends of ceramic or glass tubing, and for similar operations.

The GF3 tool cutting and grinding machine was used to display Neven grinding wheels and cutting disks; the latest model incorporates a traversing unit, but retains the principal characteristics of the earlier models. It is widely used in the ceramic and glass industries, and is also used for the preparation of geological specimens and similar work.

IDP Sparcatron equipment was shown, and, for the first time, the public could see the Sparcard surface hardening equipment. Surface hardening by the Sparcard process entails the deposition of metal on HSS tools, so as to increase their life under normal machining conditions and when used on some of the harder materials used in modern engineering practice.

Indusmond

A new departure for this company, and exhibited for the first time, was the range of diamond-impregnated furnace drills and a selection of all-coring rock drills. A range of drills for glass has also been added to the firm's list of products. Diamond wheels available range from internal grinders of 0.020 in. diameter, to wheels of 48 in. diameter.

A number of Indusmond products employ Tibond—a new bonding material recently developed by the company. Its use is at present restricted to certain applications, but development work is being carried out, and its use is likely to be extended in the near future. Established products exhibited included indexed-head turning tools, indexing truing tools, impregnated countersinks, and impregnated form tools.

A. Shaw and Sons (Diamonds) Limited

Known principally for their glass-working diamond tools, the company naturally featured a number of these on their stand; in addition, a number of diamond tools for other applications was shown. Peripheral wheels for carbide grinding, chipbreaker wheels, and honing stones were exhibited, as well as a selection of cup wheels and other diamond grinding wheels. Shaw products use a variety of metal bonds which alter the free cutting properties of the tools.

Triefus Industries Limited

It is the claim of Triefus Industries to be the only firm in the industrial diamond world that makes the complete range of diamond products; that the company's range is, to say the least, extensive, was evident from their stand.

Air-flush drilling has given the Triefus mining specialists an opportunity to develop a new coring bit for use with this medium. The bit combines large protrusion of the diamonds with an air passage system which allows for air deflexion, and which prevents any tendency to destroy soft cores through pressure build-up, blocking-off, and other causes. In this type of bit, the geometry of the holes is critical for fully efficient performance, and Triefus specialists have spent a considerable amount of time and effort in arriving at their latest design. The latest model, operating under optimum conditions, has produced a core recovery of 99%, and a 10 ft barrel has cored at 1 ft/min. Triefus drill bits have recently found a rather novel application: Harwell scientists have been using them to obtain cores from radiation shielding devices, in order to ascertain the depth of radiation penetration.

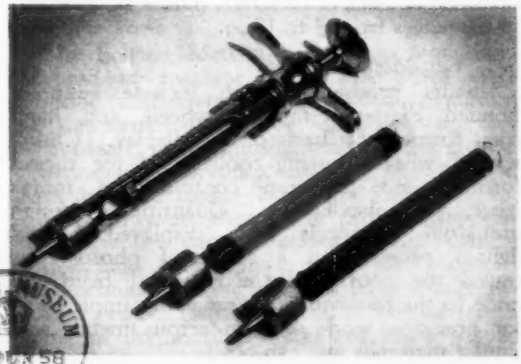
Electro-diamond tools, a selection of which was shown, are formed by an electrical bonding process, and are claimed to be complementary to diamond-impregnated tools; they are not intended to replace them. The advantages of the new type include the facts that they can be made in extremely small sizes and in almost any shape, there is little or no extra charge for tools made to the customer's specifications, and, importantly, they can be used on a variety of materials on which diamond-impregnated tools are not normally used, *eg* chrome, stellite, steel, etc.

In addition to the above new tools, Triefus also exhibited a complete range of truing tools, grinding wheels, and similar standard products, including a new pantograph for forming complex grinding wheels to a very high degree of accuracy.

L. M. Van Moppes & Sons (Diamond Tools) Limited

The display included two new products: a syringe applicator for diamond compounds, and the Diatube drill stand for use with Diatube masonry drills. The syringe applicator is a neat and well-designed instrument which guarantees that, no matter how many concentrations or mesh sizes are used in the syringe, none will be contaminated by the one previously used. This is ensured by unit construction: the syringe itself comprises a barrel and a plunger assembly; the abrasive, contained in a tube, is inserted into the barrel, and a nozzle, of a colour corresponding to the colour marking of the abrasive container, fits on the end of the syringe; the plunger can be fitted with a separate washer for each abrasive. This construction ensures that, as the washer and nozzle are the only parts which contact the abrasive, no basic part of the syringe is contaminated.

Fig 1. The L. M. Van Moppes Syringe type applicator.



SCIENCE MUSEUM
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Fig 2. From the L. M. Van Moppes stand—a Diaform pantograph wheel-forming attachment mounted on a Churchill N.B. surface grinder.

The Diatube drill stand, the other new product shown, adds versatility to the Diatube range of masonry drills. It is designed to facilitate the rapid boring of precise holes in concrete, stone, brick, and other refractory materials. The use of both drill and stand was demonstrated by an experienced operator, and excellent results were obtained in slabs of concrete. Drills are available in diameters from $\frac{3}{8}$ to 12 in.

S. L. Van Moppes Limited

Vandia products, which include resinoid-bonded diamond lapping wheels and hand laps, formed the basis of the display. Chisel-shaped wheel dressing tools, used for thread forming and precision contour and radius work, were also shown. Quantities of rough industrial diamonds were displayed behind lighted panels, and a series of photographs traced the course of the diamond from the mine to the tool-room. A range of sample tools for precision work on non-ferrous metals and similar materials was exhibited.

From other stands . . .

Hardometer hardness testing machines were demonstrated on the stand of Firth Brown Tools Limited, together with a wide variety of work holding attachments which are available for use with the machines. Literature was displayed which explained the use and applications of the testers, and the instruction book for the fixed load Hardometer presents useful theoretical notes on the Brinell and diamond tests.

The Hilger stand displayed a number of projectors for production and quality control. Several of the exhibits were shown in use—checking threads, tool profiles, and performing other operations that would be required of them in the tool-room. Particular attention appears to have been paid to the design of the screens on these instruments, and careful positioning of these has, to a large extent, helped to eliminate operator fatigue.

Ekco Electronics are devoting a large part of their research facilities to the perfecting of machine tool control equipment, and some of the latest developments were exhibited. The type E117 machine tool control provides automatic co-ordinate setting for new or existing machine tools, with a consequent reduction in scrap. Various other systems are available for allied purposes.

The Sandvik Coromant display covered a variety of tungsten carbide products, including end mills which are reported to provide simplified grinding at lower costs, longer tool life, and easy and economical change of the radial rake. These advantages accrue from the seating of the teeth at a higher angle than is required by the radial rake, and by the streamlining of the milling body. Economy in the use of diamond grinding wheels is a further important advantage.

Comment

In addition to the companies and products mentioned above, a number of articles was exhibited which were of less direct interest to the industrial diamond user. These included gauging and measuring devices, machine tools, and engineers' precision tools. The standard in all these fields was high, and the majority of manufacturers displayed their products in a manner calculated to arouse the maximum interest. The inclusion of working demonstrations was a welcome innovation, and it is to be hoped that the public response to these exhibits will encourage firms to include a greater number of these in the next Exhibition.

From every point of view the organizing association is to be congratulated on the manner in which the 1958 Exhibition was put on.

EXPO 58

Brussels Universal Exhibition

The first 'World Fair' for twenty years —opened at Brussels on April 25th by the King of the Belgians—obviously offered a challenge to the organizers to outdo their predecessors, and, so far as anyone who did not see any of the earlier exhibitions can be a judge, it is a challenge that has been most adequately met. The layout of the fair, the exciting architecture of many of the pavilions, the landscape gardening, the cascades and fountains, and, of course, the Atomium, all combine to produce a brilliant and fascinating whole.

As might be expected, in view of the large quantities of diamonds originating in the Belgian Congo and of the importance of the Belgian diamond cutting industry, diamonds and diamond mining play an important part in the exhibition. One pavilion is entirely devoted to diamonds, both as gemstones and as industrial tools, and, as well as this, a great part of the Congo section Mining and Metallurgy pavilion is concerned with the diamond mines. In addition to these specialized exhibits, diamond tools of various types are on show, in some cases being demonstrated in use, in the pavilions where machine tools are shown.

The 'Pavillon du Diamant'

The Diamond Pavilion was opened on Friday, April 25th, by the Commissioner General of the Belgian Government for the Exhibition, Baron Moens de Fernig. It contains displays of rough and cut stones shown by forty-six individual Belgian firms, as well as a demonstration of diamond cutting put on by five of the leading firms in the trade. Some of the suppliers of equipment for the diamond industry are also showing in this pavilion.

The Diamond Trading Company, Limited, in conjunction with Industrial Distributors (Sales) Limited, has a large show-case of steel, concrete, and armoured glass containing a collection of diamonds of many different types, coming from a number of sources—South Africa, the Belgian Congo, Tanganyika, and so on—valued at approximately £150,000. Some of these stones are shown in their original matrix material, others as sorted into their various classifications, according to their intended use in the jewellery trade or in industry.

The Congo Section

In the Congo Mining and Metallurgy pavilion, there are dozens of excellent photographs and colour transparencies, showing all the aspects of the Congo mining industries, and a number of working panoramic scenes, showing the layout and method of working at the mines and metal refining plant. The spectator can hear a running commentary on these models, given in any one of the principal European languages, through telephone-type handsets. In this way a very clear picture of the activities at the different establishments is provided.

Machine Tools

The Belgian Metallurgy pavilion was largely devoted to machine tools and other metal-forming machinery, and included a comprehensive demonstration by Diamant Boart S.A., of Brussels, of the cutting, drilling, and grinding of stone, glass, ceramics, and other hard materials with diamond tools. Taking the Exhibition as a whole, however, there were rather disappointingly few live demonstrations of equipment in action, and as the majority of the visitors is non-technical (unlike the case at a Trade Fair) many people must have been bewildered by some of the more complex machines. It was

certainly noticeable that wherever there was a demonstration in progress, or where the explanatory matter was more than usually full and clear, the visitor spent more time and showed more interest. As the principal purpose of these Universal Exhibitions is to show to the general public the advances that have been made in science and technology, it seems a pity that the fullest advantage should not be taken of the opportunity.

Machine tools and equipment were shown in many of the national pavilions, especially those of the U.S.A. and the U.S.S.R.; unfortunately, delays in building have prevented the opening during the first few weeks of the Exhibition of several of the national pavilions, notably those of France and Italy, so, for the initial stages at least, materially affecting the balance of the show.

Instruments, Electronics, and Automation Exhibition

Olympia, London, April 16-25

Though little of direct application to the diamond industry was shown at this year's Exhibition, several stands displayed items which are useful to the related spheres of the crystallographer and the precision engineer. The arrangement of the stands and the quality of the exhibits left little room for criticism, and an over-all effect of something-for-everybody was achieved.

Instruments . . .

Considerable interest was aroused by the stand of Mullard Limited, and by that of Kerry's (Ultrasonics) Limited, both of which demonstrated some aspect of ultrasonic machining. The Mullard stand showed the ultrasonic drill which can operate with a variety of abrasive suspensions, including diamond powder. The shape of hole obtainable by the ultrasonic method depends entirely on the ingenuity of the bit maker: squares, hexagons, and crescent shapes present no problem. The life of the bit is extended beyond what might normally be expected by a coating of the abrasive which adheres to the surface of the bit, producing an impregnated effect. Kerry's showed their ultrasonic tapping, threading, and reaming device—a new venture in ultrasonics. Diamond provides an excellent abrasive for this process, and, as with the Mullard machine, any hard and brittle material can be worked with ease. Details of both these machines are available on application to the manufacturer.

Ultrasonic flaw detection equipment was to be seen on several stands, and Kelvin Hughes showed their Mark 6 model—the latest in their range. Crystallographic instruments were strongly represented, and Unicam Instruments' exhibit included the S150 high temperature powder camera, which operates up to 1,400 deg C, the S25 single crystal goniometer, and the S35 single crystal Weissenberg goniometer. These elegant instruments typify the movement away from ugliness and ungainliness in the precision instrument field.

. . . Electronics . . .

The diamond industry, with its crystal cutting saws, probably contributes more to the electronics industry than is yet received in return. However, if electronics have a particular applicability in the diamond tool industry, it is possibly in the control of machine tools that it is most evident. Several companies showed means by which instruments may be automatically controlled, and the Ministry of Supply displayed photographs and details of the Fairey-Ferranti 3-dimensional electronic programme controlled high speed contour milling machine which can produce a surface finish within 15 micro-in.

Ceramic manufacturers were present in force, possibly because of the increasing use of ceramics by the electronics industry. The Industrial Ceramics Division of The Worcester Royal Porcelain Company displayed the high alumina Regalox product in a variety of forms. Degussit tools, a product of Degussa, Frankfurt am Main, were shown, and the manufacturers' literature available from the stand recommended the use of metal-bonded diamond wheels for the fine dressing of rotating Degussit tools. Lodge Plugs Limited displayed Sintox products, with an emphasis on its applications as an insulating material.

. . . and Automation

The automation exhibits covered a broad range, and sixteen stands exhibited machine and tool control equipment. The British Electrical Development Association's exhibit, a 'Tomic', might well have been sub-titled 'The Spirit of Automation'. The Tomic was a construction designed solely to display the various aspects of automation, and was not intended to serve, in that form, in a productive capacity. With hypnotic regularity, the machine sorted a stream of black, white, and red balls which appeared, were diverted, and disappeared in an endless procession. Though of little practical use—save, perhaps, to the snooker player—the

manufacturers were satisfied that it should serve to demonstrate conveying, light cell inspection, selection, metal detection, colour sorting, weight checking, and batching.

Impressions

Full use was made of the excellent facilities provided at Olympia, and overcrowding—the exhibition 'bogey'—was avoided by careful dispersal of the stands. Manufacturers should be persuaded to display more explanatory literature in positions where it can easily be reached, and clearer marking of stand numbers would simplify the location of individual exhibitors. Otherwise, the IEA Exhibition was extremely well organized.

It will be interesting to see just how many of this year's exhibits will have become obsolescent when the next show comes along.

New work by A. L. Pope

Mr. A. L. Pope has recently completed this fine example of diamond-point engraving on solid clear glass. The engraving depicts William Shakespeare's ' Seven Ages of Man ', in a modern setting.

The design decorates a trophy presented to the British Association of Industrial Editors by Shell-Mex and B.P. Ltd. It is to be awarded for the ' best house story of the year.'

Wheel Truing with a Hydraulic Attachment

John Waller

The formation of a vee on the larger sizes of grinding wheel is a formidable undertaking if a power operated attachment is not available, and as this process is likely to arise on both surface and rotary grinding machines, the hydraulic equipment shown in Fig 1 is suitable for either machine tool if a separately designed base member is envisaged during the initial stages of construction.

As this attachment was originally made for the latter type of grinder it required an unusually shaped base—depicted here as B—which is machined to correspond to the angular machine table; this brings the rotating member C, which carries the diamond slide, into a horizontal position, and in the correct position to pass across the face of the grinding wheel. A reference to the sectional elevation of this drawing will show these items; C is the rotating piston for operating this attachment.

The base B is cut away underneath to provide sufficient room for the clamping bolts D that hold it to the machine table, while the top face has a milled annular groove for another set of bolts that hold the rotating member, once that item has been set to the required angle. To facilitate the machining of tee slots in the rotating detail, plates are added in the conventional manner, and the long slideway gives ample guidance to the moving diamond holder, despite the fact that it needs a long stroke to pass across the grinding wheel.

Holder E is a simple mild steel piece to which the piston rod is attached—a leak-proof joint being incorporated where the cylinder is attached to the rotating detail. The pivoting is secured by a substantial shouldered pin G, which is also pinned by a cross member to overcome any tendency to disturbance; thus, on clamping the retaining bolts, a rigid and precise setting is accomplished.

One further factor also requires consideration,

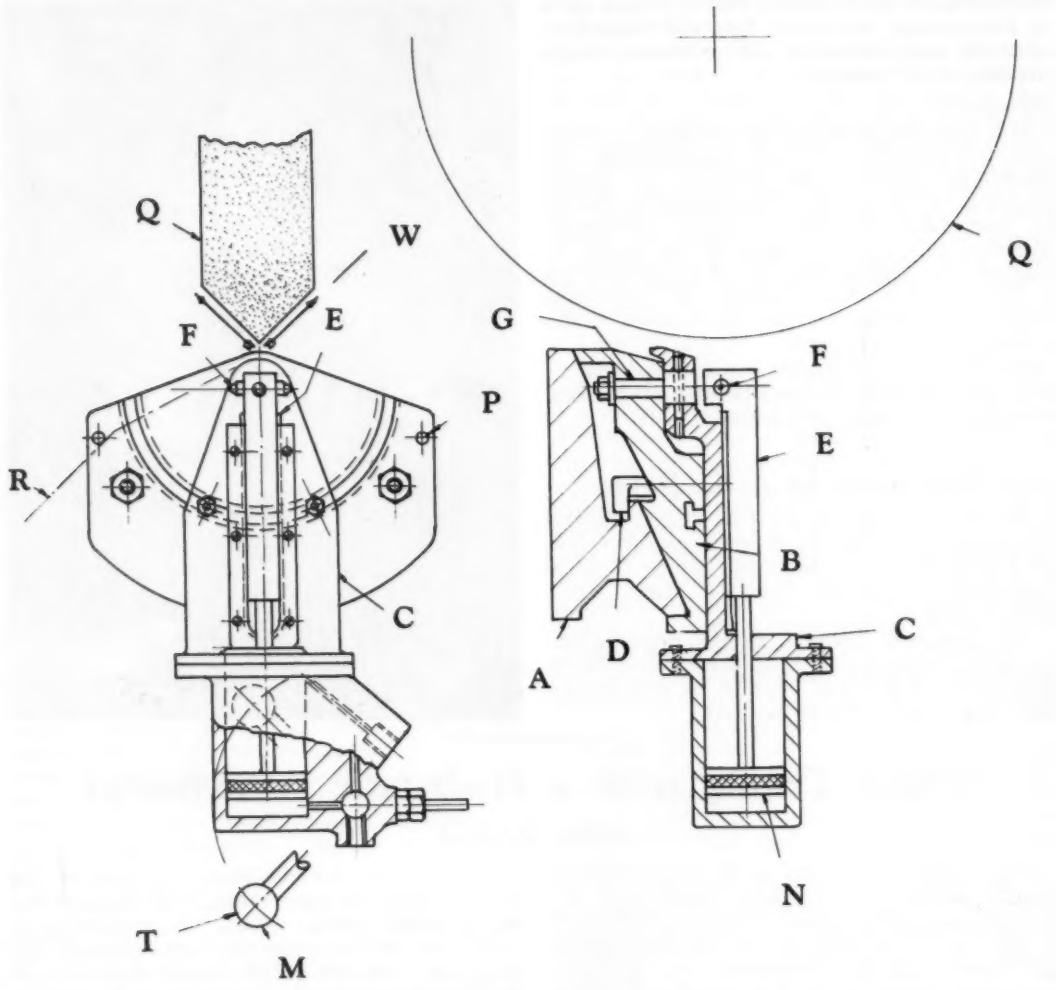


Fig 1. General assembly of the attachment showing the rotating member arranged at right angles to the wheel centre line, in an endeavour to present the details clearly.

and this concerns the final weight of the attachment. Heavy details would make it necessary to provide some form of lifting hole or bolt to facilitate removal from the grinding machine table, so that a lightly designed fabricated attachment is generally perferable to castings which are necessarily of heavier section. An assembly easily lifted on and off the machine table is the ideal design, and this is not difficult to attain if careful consideration is given to the problem.

A double-ended diamond slide is provided for when a dual passage across the grinding wheel is deemed essential, and this is held in place by the usual socket-headed grub screw; a small flat, ground on the holder, is enough to give a secure grip and to prevent rotation under cutting pressure.

An essential feature with an attachment of this nature is the degree of control when the diamond passes across the wheel face, and this is achieved by the tapered valve H and the cross drillings that restrict the oil flow to the piston; oil enters in either small or large quantities, exerts pressure on the piston, and the diamond traverses quickly or slowly past the wheel. A very fine degree of adjustment is thus possible by employing such a tapered valve, and to ensure no variation in the

KEY

A	Machine table
B	Base
C	Rotating member
D	Hook bolts
E	Diamond holder slide
F	Diamond holder
G	Pivot Pin
H	Tapered valve
J	Clamp nut
K	Valve
L	Locating plug
M	Control handle
N	Piston
P	Stop pins
Q	Grinding wheel
R	Rotating member swings to this position
S	Groove partially round valve 'H' for passage of oil
T	Position of handle while operating
U	Clearance controls the mount of oil passed to cylinder
V	Bushes
W	Passage of diamond across wheel
X	Cross holes
Y	Body

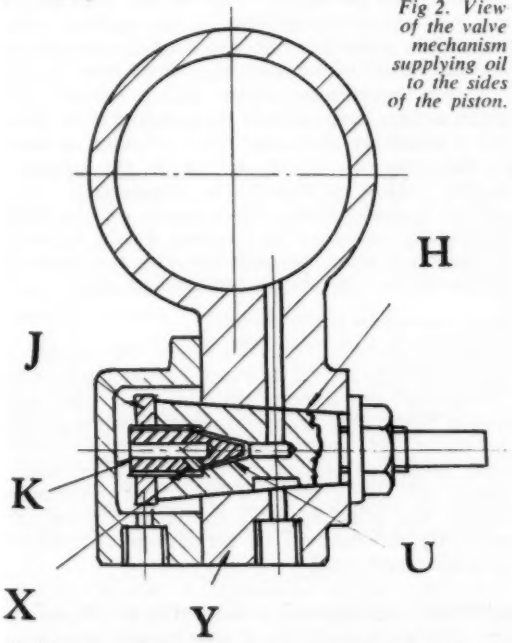


Fig 2. View of the valve mechanism supplying oil to the sides of the piston.

setting that might upset the speed at which the diamond slide traverses, a lock nut J is added to the inner valve. This inner valve K is the detail in which the drillings are made in order to allow the oil to pass.

A control handle M is attached to the tapered valve, and this, on being moved to and fro, changes the direction of the oil flow, thus causing it to exert pressure on one or the other

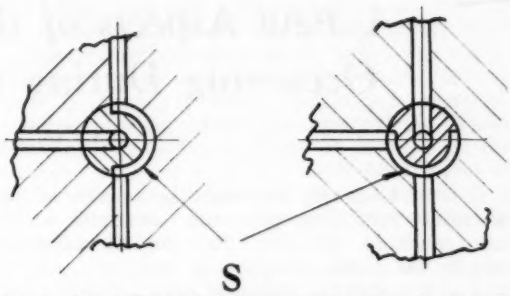


Fig 3. Sketch illustrating the groove for diverting the oil round the tapered valve.

surface of the piston. This is accomplished by the simple semi-annular groove milled in the valve, and seen with the valve in different positions in Fig 3. During the manufacture of this attachment, care is necessary in obtaining a close fit between the tapered hole and the plug of the valve—a perfectly matching taper is essential, otherwise 'sticking' will occur, making the handle difficult to operate; such a condition is also liable to cause leakage at the small end, flooding the attachment with oil. A lapping operation after boring and turning both parts, with the valve performing the duties of a lap, is the solution, and it should ensure that both parts mate accurately and without leakage.

By a slight modification to the design, various versions of this attachment are possible—the example illustrated here is ideal for those occasions when a single setting only is necessary, as the rotating member C is merely turned until it contacts the pins P, whereupon the clamping bolts are tightened prior to the diamond slide being set in motion. (*Concluded on p. 99*)

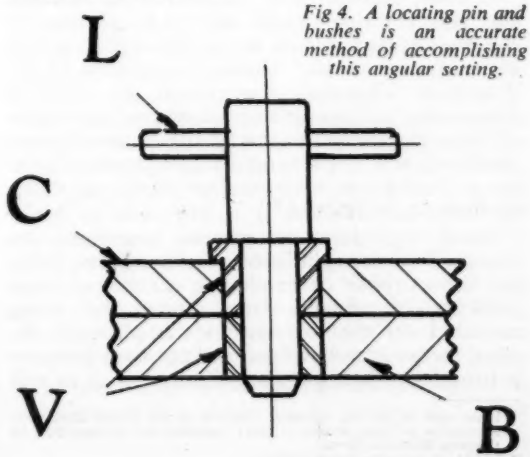


Fig 4. A locating pin and bushes is an accurate method of accomplishing this angular setting.

A Few Aspects of the Chemical Reactions Occurring During the Use of Abrasives*

Dr Vittorio Satta**

It is undoubtedly the wider knowledge of the scientific principles governing abrasion which has rendered possible the marked progress which has been observed in industrial circles and in the abrasive products during the last few years. The ' ideal ' abrasive would consist of the hardest and toughest material possible, hardness being defined as the characteristic of a body which will not allow it to be scored or scratched by any medium tending to score or scratch it. Toughness is the capacity of a body to resist impacts well, without breaking or being grazed. Both toughness and hardness depend physically on the force of cohesion between the various molecules making up the body, on its crystallographic structure and its constitution.

Best abrasive not always hardest

Unfortunately, a very hard abrasive is never very tough, and vice-versa; for instance, diamonds are exceedingly hard but very fragile; emery, on the other hand, is very tough but of limited hardness. These two products could never be used suitably and economically for roughing out and trimming steel, when a compromise must be reached between hardness and toughness by the use of corundum, which is very tough (a little less than emery but more than the diamond) and relatively hard (more than emery and less than the diamond).

It does, unfortunately, frequently happen that the best abrasive cannot always be chosen on the basis of its hardness or toughness for machining a given material. During a Congress of the American Chemical Association in 1955 at Cincinnati, L. Coes jnr insisted on the importance of research devoted to the tip life of the abrasive particles; this expression can be made clearer by a description showing how tests on it are carried out in practice.

Small cylinders of various materials are mounted on the spindle of a lathe; against these, for the purpose of producing scratches, single particles of abrasive are applied by being mounted on the toolpost in the place of the usual tools. A well defined and constant pressure is brought to bear on the cylinders, such as will not break the tips of the particles. During the test the toolpost is continually moved with an alternating motion, so that the abrasive granule makes helical marks on the cylinder. After a certain run it will be observed that the tip of the abrasive has been flattened; so much so that it can no longer make a mark, even when the pressure of the abrasive particle against the cylinder is increased.

At this point it should be observed—to bring into prominence the evidence for the chemical reactions that occur between the abrasive particle and the material of the cylinders—that the length of the scratch depends not only on the types of abrasive used and on the material composing the cylinder, but also on the atmosphere and the liquid which may be present near the tip.

It can be observed that silicon carbide will make a very long scratch on a cylinder of glass, but a relatively short one on a cylinder of steel; in the case of corundum exactly the opposite occurs. How is this to be explained ? The silicon carbide resists the attack of the glass chemically, whereas it dissolves easily in steel; on the other hand, corundum resists the chemical action of the steel, but is attacked by glass.

Heat deteriorates boron carbide

Boron carbide, the discovery of which is comparatively recent, is much harder than either corundum or silicon carbide, and for that reason there were many hopes of using it advantageously, but unfortunately it has given somewhat mediocre results; it oxidizes fairly easily, owing to the action of the heat developed during the grinding, and therefore its tip life is greatly reduced. This abrasive is affected by both glass and steel.

All the above observations would confirm that the consumption of any abrasive matter is not due exclusively to a mechanical action of breakage, nor to the excessive action of heat, as was believed until recently.

It is also necessary to examine the considerable influence which can be exerted, during abrasive action, by the various substances that may be present; that is, the coolant liquids and the so-called grinding auxiliaries. Among the simplest coolant liquids, there are water, oils, and water-based oil emulsions. In the tests with cylinders

* Paper read to the 4th National Congress of the Italian Mechanical Association at Turin, October 9, 1956; translated and abridged from *La Ceramica* 1956 (12) (Dec).

** SAIPA SA Industria Pietre Artificiali.

previously described, it is found that the presence of water sometimes shortens the length of the scratch, which would indicate that the speed of reaction is accelerated; in the particular case of corundum against steel, it seems that the water oxidizes the steel, giving an oxide which, in turn, easily reacts with the corundum, thus producing a material which is either malleable or has a low melting point. Oils, on the other hand, help in producing a longer scratch by reducing the temperature at the point of contact, or perhaps simply by excluding the presence of oxygen at the area of contact.

By ' grinding auxiliaries ' is meant any substance which assists or facilitates the process of abrasion. The simplest grinding auxiliary is perhaps air or, rather, the oxygen in the air. Tests carried out in the complete absence of oxygen have shown that no metal is removed at all by grinding. The metal undergoing the grinding action no longer forms swarf, but is pushed by the grinding wheel; in other words, there occurs a kind of superficial plastic flow of the metal. In actual fact the swarf is formed, but, as it cannot oxidize, it immediately rewelds itself to the surface of the metal where it is hot, both at the point of contact and immediately below.

When, however, oxygen is present, even in a small quantity, not only is the ground surface covered at once with a very thin layer of oxide, but the surface of the swarf also oxidizes as soon as it is formed; the formation of this layer of oxide prevents the welding of the swarf and the grinding process therefore takes place.

At this point, the difficulties which arise when grinding the so-called non-oxidizing steels may be considered; with such steels, as with all metals which oxidize very slowly, there is insufficient time for the formation of the layer of oxide to prevent the welding of the swarf. It is therefore necessary to incorporate in the abrasive material some substances forming anti-welding layers, either on the ground surface or on the swarf.

Efficiency when grinding stainless steel

We are at present doing some very interesting work on the efficiency of such substances for grinding stainless steel, not only with a view to finding the most efficient product, but also in order to have a product which will not exert any harmful effect on the properties of the bond of the abrasive body (generally a bakelite base), *ie* a product which will not weaken the adhesion between the particles. It would take up too much space here to detail all the auxiliary substances; the use of material of many different kinds has for a long time past been advocated and claimed in numerous patents and publications; they include phosphor compounds, sulphides, chlorides and organic and inorganic fluorides, such as iron sulphide (pyrites), vulcanized material, sodium chloride, chlorinated diphenyl, etc. These substances have the property of forming on the surface—as soon as it is ground—thin layers of a chloride or sulphide of the metal which is being machined, thus definitely preventing the rewelding of the swarf.

Other possible grinding auxiliaries are the so-called fillers or ' loaders,' utilized extensively in formulae for making grinding wheels with an organic bond, *ie* bakelite or rubber. Whereas some of them act as a real and true ' lubricant,' actually exerting a beneficial action on the grinding process, such as, for example, cryolite, others react chemically, either with the work which is being ground or with the swarf, these being, for example, certain derivatives of chlorine and sulphur, as already mentioned above. Others, again, such as the so-called inert mineral loaders, possess the property of rendering the organic bond more resistant to heat; this is a particularly important function, not only in the case of grinding wheels but also for flexible abrasive products.

Speed of chemical reaction important

It must also be pointed out that, when chemical actions occur between the abrasive particle (or the loading substance which is chemically active) and the worked metal, the question of the speed of the reaction plays an important part, because it is desirable to ensure the maximum removal of the swarf compatible with the minimum resistance to feed and the greatest possible freedom of cut.

Unfortunately, the reactions between the metal of the workpiece and the grinding auxiliaries are relatively rather slow for acting on the surface of the metal before the swarf is formed, or for allowing the latter to be attacked chemically in order to prevent it from rewelding itself or from clogging the surface of the abrasive body. For this reason, when machining certain metals (such as titanium), it is advisable to carry out the grinding at a low speed, giving to the grinding wheel a peripheral speed of some 10-15 metres per second (as against the 30-45 metres per second of current practice), using, if necessary, grinding fluids which are chemically very active, *ie* which have a considerable corrosive action.

In conclusion it may be said that any grinding problem which needs to be thoroughly dealt

Concluded on page 99

*In-Plant 'Diamond Mines' Are Expensive . . . . . Spot Yours and Save**

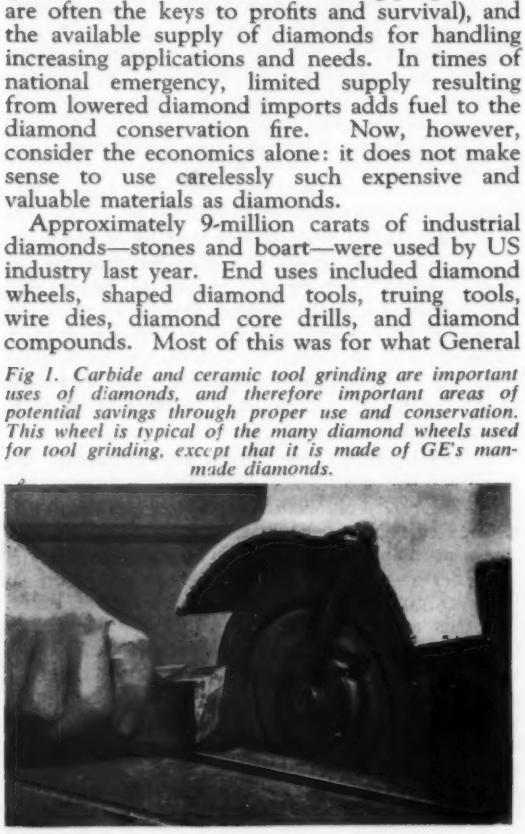
by Carol E. Reuss**

Proper use and conservation of diamond wheels and truing tools saves money and diamonds. Improper use is wasteful and expensive. Find your 'mine' and tap it.

Diamonds are important precision tools . . . and their importance and increased use will continue to rise as more complicated parts of harder materials, requiring more precision grinding, are required of the manufacturer. Conservation of diamonds goes beyond the Diamond Syndicate import limits and General Electric's ability to produce man-made diamonds. It touches two vulnerable spots—the wallet . . . (particularly now, when cost cutting programmes are often the keys to profits and survival), and the available supply of diamonds for handling increasing applications and needs. In times of national emergency, limited supply resulting from lowered diamond imports adds fuel to the diamond conservation fire. Now, however, consider the economics alone: it does not make sense to use carelessly such expensive and valuable materials as diamonds.

Approximately 9-million carats of industrial diamonds—stones and boart—were used by US industry last year. End uses included diamond wheels, shaped diamond tools, truing tools, wire dies, diamond core drills, and diamond compounds. Most of this was for what General Electric's Dr Guy Suits calls 'premium applications,' because "industry cannot afford to use \$7,000-\$9,000/lb material for applications which require only 50 cents/lb abrasives." But premium applications are increasing: consider the manufacturing and/or requirements for high speed, high strength aircraft, as just one example. Consider increasing use of carbide tools, dies, and wearparts as another.

Fig 1. Carbide and ceramic tool grinding are important uses of diamonds, and therefore important areas of potential savings through proper use and conservation. This wheel is typical of the many diamond wheels used for tool grinding, except that it is made of GE's man-made diamonds.



More than half of the diamond yield from blue ground, or diamond-bearing rock, ends up as industrial diamonds and boart—2½ ct of the approximately 4½ ct found in 35 tons of blue ground. Most of this is boart from which grinding wheels and lapping compounds are produced. As a result of this, and also as a result of industrial needs, the greatest end use of diamonds is for grinding wheels—specifically for grinding carbides. By the same token, the greatest diamond conservation possibilities lie within the realm of grinding. So, says Carborundum Company's John W. Ripple, "a vigorous programme of conservation and salvage of diamonds used in diamond wheels can save money for the user, real money if the wheels are used in appreciable quantities." Proper use, in his estimation, is number one on the conservation list.

Diamond specialists gave the following suggestions for conserving boart about five years ago, when the government restricted diamond use, and all industry joined efforts to decide on ways and means of conservation. They are still valid and valuable today:

More efficient use of diamond wheels in conventional grinding by employing conditions which result in the largest possible amount of stock removal per carat of diamond.

Substitution of silicon carbide abrasive wheels for diamond wheels, where possible.

Consideration of non-conventional 'grinding' processes developed to procure greater stock removal per carat of diamond.

A fourth suggestion—use of abrasive belt methods for grinding carbides—was the result of efforts by abrasive belt and machine manufacturers to find a way to substitute for diamonds which were in extremely short supply. Many machines sold for belt finishing carbide tipped tools are still successfully in use, but the idea did not take too strong a hold as a full-range

* Reprinted by permission from *Tooling & Production* 1958 Vol 33 (11) pp 67-78 (Feb); (12) p 69 (Mar)

** Associate Editor, Tooling & Production

substitute for diamonds. As long as diamonds are available, a Behr-Manning spokesman believes, "they hold the dominant position for tool grinding." Diamonds are more economical than coated abrasive belts, he adds, for carbide tool finishing.

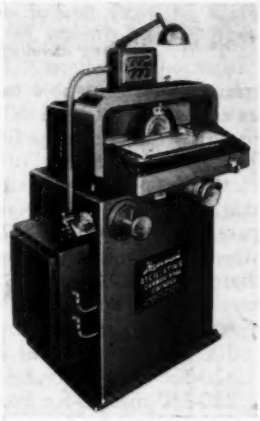
Limiting the conservation problem to carbide tool grinding, consider this data: it has been estimated that it costs between $20 and $30 to grind a cubic inch of carbide. To cut this cost, or to hold it at a minimum, takes (*i*) proper wheel selection and application, (*ii*) proper use of coolants, (*iii*) good machines, and (*iv*) an effective diamond salvage programme. Diamond salvage and wet grinding can each account for at least 10% saving in wheel cost. It is advisable to examine all facets of a diamond grinding programme to spot all the money- and diamond-saving possibilities.

Because of diamond's unsurpassed hardness, it is sometimes the only material which can be used to shape other hard materials. In other instances the diamond is used unnecessarily, and can be replaced economically and acceptably by different materials and/or methods, without endangering finished product quality. In general, it is reasonable to assume that any technique that saves diamonds—whether by lengthening their useful life, or by replacing them with acceptable results insofar as the finished product is concerned—is a conservation method and should be followed. Proper selection and efficient use of the various types and grades of diamond wheels is a first step in the diamond conservation programme.

Basically . . .

No one diamond wheel can do all things for all grinding operations. Economical selection depends on many things, including available equipment, availability or non-availability of adequate coolant, the grinding job itself, and the special features of each of the various types of wheels.

Fig 2. Hold the carbide tool in a fixed position, and allow the oscillating wheel to do the lateral moving. This is how the oscillating grinders, such as these manufactured by Wesson Co and Hammond Machinery Builders Inc, simplify tool grinding.



Reviewing the basic principles of abrasive and diamond wheels, we find that:

Concentration is the ratio between the diamond particles and the bonding material: for carbide grinding, three concentrations are recommended: 100 concentration, giving maximum number of diamonds; 75 concentration; and 50 concen-

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Fig 3. A heavy flow of coolant is more effective for diamond wheel grinding, but not all machines can handle it; operators usually dislike working in it.

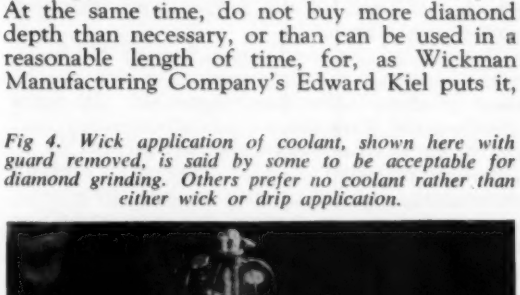
tration. Some wheel manufacturers speak only in terms of 100 and 50 concentration, but one recently introduced a 150 concentration wheel. The actual number of diamonds to bonding material is not fixed, but varies among wheel manufacturers, thus making it difficult to compare wheels fully and adequately. *Mesh* or *grit* size is the diamond particle size. A survey of diamond wheel manufacturers indicates that mesh sizes are as follows for carbide grinding:

80 mesh—very coarse, for heavy stock removal,
100 mesh—for rapid stock removal,
120-150 mesh—for off-hand sharpening,
220-250 mesh—for finishing,
320-400 mesh—for fine finishing, and
500 and finer—for mirror finishing

Combining concentration and diamond particle sizes, some wheel manufacturers recommend 100 concentration for wheels under 220 mesh; 75 concentration for 220 mesh and finer and dry wheels; and 50 mesh for vitrified and metal-bonded cup wheels for off-hand grinding, and for finer resinoid-bonded cup wheels. The Industrial Diamond Association recommends medium concentration for most off-hand grinding operations. But, they add, some operations, such as small tool finishing, take higher concentration wheels to avoid over-heating, wheel-clogging, and checking. Then, they say, use light pressure and still get rapid stock removal.

Fixed-feed grinding usually requires high concentration wheels, but medium concentration is all right with 220 and finer mesh sizes. Higher concentration is especially important in production shops, where high labour costs demand that the work be done as fast as possible. Use high feed pressure and high diamond concentration in such instances. For economy, buy the highest concentration suitable for the job. At the same time, do not buy more diamond depth than necessary, or than can be used in a reasonable length of time, for, as Wickman Manufacturing Company's Edward Kiel puts it,

Fig 4. Wick application of coolant, shown here with guard removed, is said by some to be acceptable for diamond grinding. Others prefer no coolant rather than either wick or drip application.



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"depth does not affect grinding ability . . . concentration does." As for selection of size, always use the coarsest size commensurate with the finish required. Larger diamond particles can be retained in the wheel longer, so the wheel lasts longer but are not suited for fine finishes. At the same time, fine wheels should not be used for heavy stock removal. Rough grind with coarse wheels; finish with fine.

The bond holds the diamond particles in the wheel securely, yet does little or no real cutting. Its role is to keep sharp diamond points in contact with the work by wearing away, as diamond particles become dull, to expose new diamond cutting points. It determines cutting action and wear. If the bond is soft, for instance, the diamond particles tear out easily, giving free cutting action but wearing faster. If the bond is hard, the diamond particles stay in the wheel longer, the wheel itself wears more slowly, and the cutting action is slower. The optimum relationship between bond, size, and concentration would be a bonding material which would wear at the rate at which the diamond particles become dull. In that way, the dull particles would fall or be torn out of the wheel just as they become dull, and new diamond points would be uncovered just as they were needed. The grade or hardness of the diamond wheel, as with other abrasive, is the resistance the bond offers against letting the abrasive be torn out of the wheel to expose sharp cutting edges. This varies among bond types and manufacturers.

To be continued

Polymer analysis course

The National College of Rubber Technology is holding a short course this Summer for the purpose of introducing physical methods to analysts in the polymer field. The course will be held at the National College of Rubber Technology, Northern Polytechnic, Holloway Road, London N 7. Further details are available from the organising lecturer, Mr. D. A. Smith, and enquiries should be addressed to him, at the College.

Chemical Reactions

Concluded from p 95

with technically and economically requires extensive scientific research, even if this is only done to give a satisfactory answer to the always increasing requirements of the consumers of abrasive materials.

Wheel Truing

Concluded from p 93

On the other hand, when different vees are required, a positive setting of this nature is not feasible, and a dial is needed similar to that used for top-slide setting on a centre lathe. A graduated scale arranged on the base member solves this problem, and a close degree of accuracy is accomplished by incorporating a vernier scale on the rotating part.

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